

TITLE OF INVENTION

Multivariate Negotiation with Satisfaction Ratings

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit, under 35 U.S.C. 119(e), of US Provisional Application No. 60/448,125, filed February 20, 2003.

BACKGROUND OF THE INVENTION

The present invention relates in general to a computer-based decision support system for multiple parties involved in any type of negotiation. In complex negotiations, the system assists parties in reaching an optimal agreement in terms of the individual and overall joint gains.

Negotiation is a process where two or more parties with conflicting objectives attempt to reach an agreement. This process includes not only bargaining (the presentation and exchange of proposals for addressing particular issues), but also the attempts made by each party to discover and use knowledge of the preferences, strengths and weaknesses of their opponents to reach a resolution that satisfies their own objectives while still being acceptable to other parties. Negotiating parties may be individuals or teams, representing their own interests or the interests of their organizations. When there is at least some willingness to engage in negotiation, it can be a constructive alternative to other means (e.g., stalemate, litigation, violence) of settling disputes.

Negotiators have several basic tasks, which are non-trivial when there are many decision variables (issues) in a negotiation:

- Qualify Interests: Identify potential agreements.
- Quantify Satisfaction: Determine how party becomes satisfied.
- Establish Equity: Agree on how gains should be divided.
- Maximize Gains: Find an outcome that maximizes joint gains.
- Secure Commitment: Insure that the agreement will be implemented as intended.

In order to accomplish these tasks, negotiators must explore the impacts of various decisions, and at least begin to understand the tradeoffs among these impacts. A third party mediator and/or facilitator may be included in a negotiation process to help manage the interactions and offer suggestions for negotiating parties to consider. Alternatively, an arbitrator may be involved with the power to draft and perhaps dictate settlements for the parties. It is commonly recognized that such disinterested parties can significantly help negotiators in their quest for an agreement.

Recent developments in modeling negotiation processes, such as more powerful computers, and the maturing of the Internet, are motivating research in the use of computer-based analysis and network solutions for complex negotiation problems. State-of-the-art interactive interfaces today permit the updating of case descriptions, decision variables, preferences, and interested stakeholders as the negotiation process proceeds.

The current literature on interactive computer programs for multi-objective conflict resolution commonly uses the term “negotiation support system” or simply “negotiation system”. This term refers to the special type of group decision support system designed for providing assistance in situations where there is conflict among various parties as to what decisions to adopt. Research addressing group decision making in multi-objective situations is in its fourth decade, yet the development and use of negotiation systems to facilitate and help guide multi-party negotiations is still considered a relatively new field. Numerous efforts are underway in various kinds of negotiation systems. Existing systems vary from very simple systems for automated single variable blind bidding (usually with money) (e.g., CyberSettle (www.cybersettle.com), ClickNsettle (www.cybersettle.com) to more sophisticated multivariate systems such as Inspire and WebNS (<http://interneg.org/interneg/research/papers/2003/02.pdf>).

Multivariate systems are generally designed to provide a practical means of increasing the likelihood of mutually agreeable settlements when there exist many possible outcomes on many issues. Sometimes these systems can help identify better solutions than would have been found without their use. The majority of systems described in the literature for complex negotiations, are still in the conceptual stage, or, at best, play a relatively passive role in the negotiation process. The one prior art multivariate negotiation system that stands out in its ability to substantially aid negotiating parties in a complex real-world setting is ICANS, as described in US Patent 5,495,412 and presently implemented in **SmartSettle** (www.smartsettle.com).

Negotiation systems have one thing in common, in that proposals are made in terms of which decisions to make on the various issues. In the case of systems that only deal with a single issue or variable, a proposal consists of a single number and it is obvious how to propose another number that is better for the other party. Although these single variable systems have a very limited application, they obviously enjoy the advantage of simplicity. Multivariate systems, on the other hand, which are designed to keep preferences of negotiating parties confidential, are much more complex. Since preferences of other parties are generally not known, a negotiator cannot be sure what their party's concession, consisting of a different set of values, will actually mean to the other party. Achieving efficiency and fairness objectives under these conditions is no easy task.

BRIEF SUMMARY OF THE INVENTION

A computer-based interactive system for supporting multivariate negotiations is disclosed. This system enables decision makers in multivariate negotiations to simply exchange satisfaction ratings, while still meeting the objectives of efficiency and fairness. In effect, this process simplifies the negotiation to exchange of single numbers, just as if the decision makers were negotiating over a single variable. The method described here improves upon that described as ICANS in Patent 5,495,412 and the improvement described in US Patent Application No. 10/022,797. Where the presently disclosed system is very similar to existing systems, these similarities are summarized here rather than repeated in detail.

As in said previously described system, the presently disclosed system assists any number of parties involved in simple or complex negotiations with any number of variables in reaching an agreement that optimizes both individual and joint gains for the parties. Parties using the system can have their own separate computer systems networked by a neutral site that manages data in such a way that each party's preference information remains confidential to that party.

The system first elicits a problem description and preferences from each negotiating party. The problem and preferences are modeled by the system in such a way that a satisfaction rating can be produced for any possible outcome. The parties begin by collaborating in building a “framework for agreement”. The framework for agreement is like a final agreement except for blanks representing unresolved issues. It may also include constraints that relate two or more variables. From the framework for agreement, a list of decision variables can be derived and entered into a computer system. Each of the parties in a conflict or dispute to be negotiated then enters their own preferences concerning each decision variable of the conflict into the computer system. They may also enter private variables and/or private constraints if this provides a better problem description.

Preference information includes data on satisfaction functions for each of the variables. Each satisfaction function defines a party's relative level of satisfaction as a function of a numerical value for the outcome of that variable. The preference information for each party includes more preferred and less preferred outcomes that define bargaining ranges and a relative importance assigned to each variable with respect to its bargaining range. Bargaining ranges define a region in which a party's satisfaction is defined for feasible packages (sets of values for each variable representing potential agreements) created within those bounds. Every package that is created by any party or by the system is associated with a specified level of satisfaction or rating for each party that is determined by the satisfaction function for that variable and relative importance of that variable. Each party has a private view in which packages are rated according to their own preferences. Parties may create any number of packages for their own private consideration or proposals and/or other packages for discussion purposes. Once the system has received the negotiation problem model and preferences from the negotiating parties, it can also generate various types of packages.

Parties may declare their acceptance of any package. Such acceptance may be kept confidential until other parties have also accepted that package. If two or more parties accept the same package, that package becomes a tentative agreement among those parties.

Proposals are defined as packages with published acceptance. Parties may choose to submit proposals in sequence or simultaneously. As an alternative to proposing a package of actual values for each negotiation variable, parties can be given the option of simply proposing a rating to the other negotiating parties. This type of proposal will be referred to here as a visible **Reflection** in a process defined below. Figure 1 defines various terms used below in the description of a negotiation process with visible **Reflections** in the context of a hypothetical two-party negotiation scenario between Party A and Party B.

In order to keep preferences confidential, it is assumed that our negotiating parties would not want packages on the Efficiency Frontier to be revealed until they have decided how gains are going to be divided. Visible **Reflections** can give negotiators the best of both worlds in this situation, i.e. pointing them to an optimal solution without revealing preferences by showing parties the actual values that would make up that solution.

For the purposes of this illustration, suppose the parties propose **Reflections** simultaneously. Using a suitable optimization technique, looking at all packages, given the constraints of the problem (including a buffer if any), the system determines the maximum possible rating that is possible for each party while still allowing the other party to achieve a minimum specified level of satisfaction for themselves. Each of these maximum possible ratings is proposed to the opposing party.

Visible **Reflections** in this system are represented by actual packages. Parties may propose as many visible **Reflections** as they wish, each time making a concession by reducing the minimum rating that they have declared acceptable. When one party declares that a package with the rating proposed by the other party is acceptable, the system automatically generates a unique Equivalent package for both parties that would give them a level of satisfaction at least as great as those ratings that they have each declared to be acceptable.

The disclosed system also allows the parties to propose a rating in confidence (a new method of multivariate (multi-issue) blind bidding not described in US Patent Application No. 10/022,797). In this case, the “hidden” reflected ratings are not shown to the other party until it is possible to generate a solution that simultaneously satisfies both parties. A scenario using hidden **Reflections** is shown in Figure 2.

Packages that are generated by the system are done so using optimization techniques. The preferred method of optimization uses standard mixed-integer linear programming techniques to solve an appropriate optimization problem that takes into account the preference information of the parties and obeys any shared or private constraints that have been defined. If a problem cannot be represented in such a way as to allow linear optimization, non-linear methods may also be applied.

“Minimizing the maximum gain” represented by a generated package relative to accepted packages is one technique that may be used to generate an equivalent package (in terms of satisfaction levels) for two or more parties to consider. Once parties have reached a tentative agreement by any means, parties may request the system to search for an improvement in terms of satisfaction levels for all parties. A very good optimization algorithm for doing this is called “Maximizing the minimum gain”. Both of these algorithms are described elsewhere.

For maximum security of all party's confidential information, a separate computer system located at a neutral site can be connected to each individual party's computer system. In this case, packages are generated at the neutral site and transmitted back to each party's own computer system. Encryption is used to maintain transmission security. This entire system may be automated in repetitive negotiations in which the computer systems controlled by the parties may derive required input information from simulation models rather than that information having to be explicitly entered each time.

The main advantage of the disclosed system over previous systems is that it enables decision makers to quickly reach an agreement that is both fair and optimal by apparently negotiating with a single number that represents their satisfaction level for outcomes composed of values for any number and type of variables.

BRIEF DESCRIPTION OF THE DRAWINGS

There are two figures appearing as drawings that are used in this application for the purposes of illustrating a process that we have named **Reflections**. These figures are referred to in the “Brief Summary of the Invention” and again in the “Detailed Description of the Invention”. These figures illustrate a hypothetical negotiation between two parties, named Party A and Party B. Each figure is a graph of the “Satisfaction of Party A” plotted against the “Satisfaction of Party B” for any possible outcome of the negotiation.

The origin on these graphs, labeled Nash Equilibrium on Figure 1, represents the level of satisfaction that each party would achieve if no agreement were reached. These levels are also lower bounds for satisfaction levels of all feasible potential agreements. The Efficiency Frontier, which is the set of optimal potential agreements defined by the constraints of the problem, represents an upper bound of all feasible potential agreements. Also shown on Figure 1 is a buffer, which can be set to absorb any errors in preference representation and/or as a basis for incorporating process fees.

Figure 1 depicts a scenario where Party A and Party B have each proposed a visible **Reflection** represented by a level of satisfaction that they have declared acceptable (AA and BB respectively). These **Reflections** are represented in each party's own view by packages labeled as A1 and B1. The satisfaction that these packages would deliver to the other party can be deduced from the drawing but in the actual negotiation is unknown to either party and also irrelevant to the process.

In the graphic views of the parties receiving the generated ratings, incoming **Reflections** are represented by satisfaction levels of AB (Package B2) for Party B and BA (Package A2) for Party A. Satisfaction level AB is the maximum possible rating that is possible for Party B, while still allowing Party A to achieve a satisfaction rating of at least AA. Satisfaction level BA is the maximum possible rating that is possible for Party A, while still allowing Party B to achieve a satisfaction rating of at least BB. Packages A2 and B2, which are generated by the system, can appear anywhere on their own line.

The scenario in Figure 1 assumes that Party B accepts package B2 and the system responds by generating an Equivalent package E. After both parties accept Equivalent package E, it becomes a Tentative agreement and an Improvement is generated, represented by package I.

Figure 2 represents a different scenario where hidden **Reflections** are proposed with packages that are accepted confidentially by the parties. Parties first propose hidden **Reflections** with packages A3 and B3 but these packages are too far apart to produce a response from the system. Packages A4 and B4, which represent concessions compared to A3 and B3, are close enough so that the system can generate an Equivalent package E. When both parties accept Equivalent package E, it becomes a Tentative agreement and an Improvement is generated, represented by package I.

DETAILED DESCRIPTION OF THE INVENTION

Overview

The present invention improves one aspect of a previously described system called **ICANS** (US Patent 5,495,412) and implemented by a negotiation system called **SmartSettle** (described in US Patent Application No. 10/022,797) with a new method called “Multivariate Negotiation with Satisfaction Ratings” or **Reflections** for short. The **Reflection** method is described here in the wider context of the original **ICANS** method in order to illustrate the most preferred embodiment of the method and to assist the reader in more completely understanding the invention. The disclosed system is intended to be implemented shortly by an updated release of **SmartSettle** at www.smartsettle.com and will be referred to by that name throughout this description.

In general, **SmartSettle** is implemented on a computer by providing the negotiating parties with an acceptable interactive graphical interface. It assists any number of parties involved in simple or complex negotiations with any number of decision variables in quickly reaching an agreement that maximizes the joint gains of all parties. If desired, each party to the negotiation can have a separate computer system in a network with a neutral site so that each party's preference information remains confidential to that party.

SmartSettle requires parties to first collaborate in building a framework for agreement. The framework for agreement may include constraints that relate two or more variables. From the framework for agreement, a list of decision variables can be derived and entered into a computer system. The system then needs to elicit at least a minimum amount of preference information from each party for the purpose of representing preferred outcomes, bargaining ranges and satisfaction ratings for packages. Parties may also enter private variables and/or private constraints if this provides a better problem description. With preferences well represented, **SmartSettle** enables parties to generate optimal solutions to their negotiation problem and propose visible **Reflections** that show parties the maximum possible satisfaction of a potential agreement without actually showing them the values of decisions corresponding to that potential agreement. When parties have accepted satisfaction levels that are close enough to each other, **SmartSettle** reveals the optimal package that shows the actual decisions that parties would need to agree to. Parties can confirm their willingness to make those decisions by placing a confidential acceptance on the actual package. When two parties accept the same package an agreement is declared.

Preferences Required for Package Evaluation

Before parties can enter information regarding their preferences on the outcome of a particular variable, a range of outcomes for that variable must be defined. This range is referred to here as a bargaining range. Within this range, **SmartSettle**, by default, generates a linear relative satisfaction function to define that party's relative level of satisfaction as a function of a numerical value for the outcome of that variable. However, the party has the option of changing that function to more accurately describe their relative satisfaction function by picking points on the graphical interface.

With bargaining ranges defined, packages (sets of potential values for each unresolved variable) can be identified. Every package that is created by any party or by the system is associated with a specified level of satisfaction or rating for each party that is determined by the satisfaction functions and relative importances for each variable included in preference analysis. Each party has a private view in which packages can be evaluated according to their own preferences.

SmartSettle provides a number of ways for each party to define the satisfaction tradeoffs between variables that determine the relative importance of each variable with respect to its bargaining range. These ways have been described earlier (see given patent references) and will not be repeated in detail here.

Types of Packages

SmartSettle uses the ranges, satisfaction functions and satisfaction tradeoff information to generate a rating that represents the relative total satisfaction value that each package would provide to a party. Once **SmartSettle** has sufficient information with which to rate packages, parties can create packages that may either be private, or published for other negotiators to see. Published packages may be declared as proposals for acceptance or simply for discussion purposes.

Parties may also select from a menu, any one of several other different types of packages for **SmartSettle** to generate; Split, Suggestion, Equivalent, Improvement, Optimized Equivalent, or Dominant. Except for Equivalent, each of these functions always simultaneously generate an identical package for all parties, defined as follows:

- **Split:** a package that provides each party as close as possible to, but not less than, the average of the satisfaction ratings of existing party proposals.

- **Suggestion:** a package that falls between other existing packages (proposals and other Suggestions) in terms of satisfaction ratings to each viewing party.
- **Equivalent:** a package that is equivalent, in terms of satisfaction ratings, to a party's least preferred acceptable package (published or private) but different enough, in terms of values for each variable, to allow a party to check their preferences. If two or more parties have made proposals or have accepted packages that are close enough to each other (in terms of satisfaction levels), the system may generate an Equivalent that simultaneously satisfies all parties by providing approximately the same level of satisfaction that they have declared acceptable. With confidential acceptances, this functionality allows the system to solve visible or invisible impasses. Whether or not **SmartSettle** has generated different packages for all parties, or the same identical package for all of them, is not revealed to any party unless they accept that package. In that case, it will either become an agreement or the system will demote the package to a private group.
- **Improvement:** an optimal package that is better than the tentative agreement for at least one party and not worse for any others. An Improvement attempts to fairly divide gains among all parties relative to a Tentative agreement.
- **Optimized Equivalent:** a package that is as good as possible for other permitting parties but still equivalent to the least preferred acceptable package of the party requesting the package. If there are more than two other permitting parties, gains are divided equally.
- **Dominant:** an optimal package that attempts to fairly divide gains or losses among all parties relative to existing proposals. This outcome of this procedure is the same as if a Split had first been generated and then an Improvement.

Reflections

Reflections are introduced in the presently disclosed system as a new method of negotiating. **Reflections** allow decision makers to negotiate in complex multivariate cases by exchanging optimal satisfaction ratings rather than actual packages. A **Reflection** may be visible to other parties or hidden (kept confidential).

In the case of visible **Reflections**, one party indirectly “proposes” a maximum rating to other parties. If a party had very high confidence that its preferences were well represented by the system and was thoroughly familiar with that representation, the system could simply display that rating. However, assuming that this is usually not the case, the system described here reveals reflected satisfaction ratings in the context of a package of actual values that would produce the specified level of satisfaction.

In order to keep preferences confidential, the system is deliberately designed not to show the optimal package associated with a reflected rating. It might do so by coincidence but no parties would know that. Usually, there would be theoretically infinitely many packages that would result in a specified level of satisfaction to any party. Rather than choose a package at random, the system looks at values in packages that parties have already created and accepted themselves and uses these values as targets. In this way, parties can influence the values that the system chooses to create a package with the specified level of satisfaction. Parties may request any number of packages to be generated with the specified rating. Examining these packages and confirming that they are rated accurately will increase their confidence that their preferences are adequately represented.

When a certain party reflects a proposal to other parties, those other parties may consider whether or not to accept it. When parties accept a reflected proposal, they are not accepting an actual package proposed by the initiator of the proposal but rather just the rating. When all parties (or a subset if coalitions are allowed) accept a reflected proposal, SmartSettle automatically generates an Equivalent package. A tentative agreement is reached when all parties accept that Equivalent package

Hidden **Reflections** are discussed in the context of multivariate blind bidding in the following section.

Multivariate Blind Bidding

The previously existing method of multivariate blind bidding available to users of **SmartSettle** uses visible packages. In this method, **SmartSettle** receives published proposals or bargaining ranges and responds with visible packages that are generated as a function of user preferences as described above. Parties can see packages that are generated by **SmartSettle**, but are “blind” to a confidential acceptance that any party may indicate with respect to any package. When at least two parties accept the same package, an agreement is declared between those parties.

Another method of multivariate blind bidding introduced in this disclosed system uses invisible ratings. In the **SmartSettle** interface, this is called “reflecting a Suggestion”. Technically, this merely requires each user to accept a rating corresponding to an acceptable level of satisfaction, although, in **SmartSettle**, this is implemented by requiring parties to accept a package that has the acceptable rating. When parties have accepted ratings that are close enough, **SmartSettle** will generate an Equivalent package, i.e., a unique package that simultaneously satisfies all negotiating parties. If parties accept said Equivalent package, it becomes a Tentative agreement. Although this Tentative should already be relatively efficient within the given constraints, it can also be subsequently optimized.

Optimization Methods

Whenever **SmartSettle** generates any type of package, it does so by solving an appropriate optimization problem. The preferred method is to use standard mixed-integer linear programming techniques to solve an appropriate optimization problem. If a problem cannot be represented in such a way as to allow linear optimization, non-linear methods may also be applied.

Whichever optimization method is used takes into account the preference information of the parties and obeys any shared or private constraints that have been defined. Equivalent may use an algorithm referred to as “Minimizing the Maximum Gain”, comparing existing packages to a newly generated package. Improvement uses an algorithm referred to as “Maximizing the Minimum Gain”. In this method, once parties have reached a tentative agreement by any means, parties may elect to have an optimal agreement to the conflict determined by “maximizing the minimum gain” in satisfaction achieved by each of the parties in going from the tentative to an improved package of variable values. This will, at the same time, maximize joint gains for all the parties. For further details regarding those algorithms, see the description for US Patent 5,495,412 (ICANS).

Multivariate blind bidding is implemented in **SmartSettle** with a routine called Suggestion, which can be published or reflected. In general, the objective of the published Suggestion model is to generate Suggestions that fall between other Suggestions, while filling the largest gaps, with priority on filling those gaps that fall between those packages that have already been accepted. This method tends to produce more efficient packages when parties are close together, thereby resulting in a final tentative agreement that lands relatively close to the Efficiency Frontier. The output of the reflected Suggestion model generates an Equivalent that is also relatively close to the Efficiency Frontier.

Since parties to the negotiations normally wish to have their preferences kept confidential, a neutral site networking separate computer systems for each of the parties is necessary. The separate computer systems can be programmed to carry out all of the initial calculations including generation of the relative satisfaction functions for each variable and generation of the total satisfaction for each package. This information can then be transmitted to a central computer system at a neutral site which processes all of the preference data from each of the parties, uses this information to generate requested packages, and transmits the results back to each of the parties. Encryption is used to maintain transmission security. This entire system may be automated in repetitive negotiations in which the computer systems controlled by the parties may derive required input information from simulation models rather than that information having to be explicitly entered each time.

Illustration

The illustration that follows refers to the figures in the drawings section. It uses two scenarios of a hypothetical simple two-party negotiation between Party A and Party B. Figure 1, which illustrates Scenario I, also defines various terms used below in this description of a negotiation process with **Reflections**. Although our negotiators have decided to cooperate with negotiation, they still wish to keep their preferences confidential, at least until it is determined how they are going to divide the gains from this negotiation.

Suppose that the parties here have begun their negotiation by exchanging conventional proposals and now wish to continue with **Reflections**. They have opted to propose these **Reflections** simultaneously. Party A defines a package named A1 that has a satisfaction rating of AA in their private view. Party A selects said package and chooses to propose a **Reflection** of that package to Party B. At the same time, Party B defines a package named B1 that has a satisfaction rating of BB in their private view. Party B selects said package and chooses to propose a **Reflection** of that package to Party A.

Since parties have opted to reflect their proposals simultaneously, **SmartSettle** waits until they are both ready. Using a suitable optimization technique, given the constraints of the problem (and buffer if any), **SmartSettle** then determines the maximum possible rating, that is possible for each party while still allowing the other party to achieve a minimum specified level of satisfaction for themselves. Each of these maximum possible ratings is proposed to the opposing party, AB to Party B represented by package B2 and BA to Party A represented by package A2.

Since this negotiation involves many decision variables, and is therefore quite complex, neither party has a lot of confidence that their preferences are well represented by the system. It is therefore reassuring to be able to associate the proposed rating with an actual set of values for the negotiation variables. If either party is not confident about how well their preferences are represented by **SmartSettle**, they can request additional Equivalent packages to be generated for checking purposes. Parties can adjust their preference representation at any time during the process.

Party A examines package A2 while Party B examines package B2. While Party A is still considering A2, Party B decides that B2 with rating AB is acceptable and declares that to **SmartSettle**. When s/he does that, **SmartSettle** automatically generates a unique Equivalent package for both parties that would give them each as much satisfaction as they have indicated acceptable (labeled E on Figure 1). With preferences well represented by this time, both parties accept Equivalent E and request an Improvement (labeled I on Figure 1).

In Scenario II, parties choose to propose a rating in confidence, i.e., reflect Suggestions rather than Proposals. In this case, there is no such thing as acting simultaneously or taking turns since neither party knows what the other is doing. At some point, Party A reflects the package named A3. Meanwhile Party B reflects the package named B3. Sometime later, Party A reflects a package named A4. Sometime after that, when Party B reflects a package named B4, **SmartSettle** determines that parties are close enough to generate an Equivalent and does so automatically, resulting in package E. With preferences well represented by this time, both parties accept Equivalent E and request an Improvement (labeled I on Figure 2).